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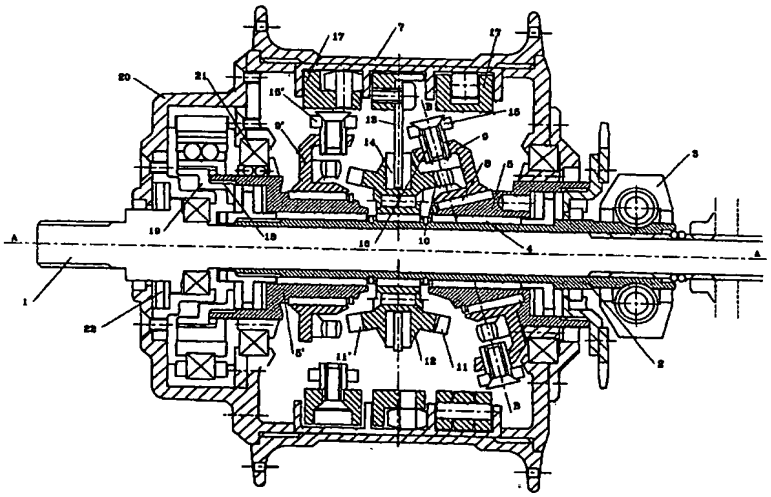
(54) Title: VARIABLE-RATIO TRANSMISSION DEVICE



(57) Abstract: A variable-ratio transmission device is disclosed comprising: a support shaft (1); an hollow shaft (5) rotatingly assembled onto the shaft (1); a support (9) assembled onto the hollow shaft (5) in a rotating way with respect to the shaft around a slanted axis with respect to an axis of the support shaft (1); a plurality of rollers or teeth (10) arranged in a circular series on the support (9); a wheel assembled idle onto the shaft (1), equipped with a front toothing (11) adapted to be engaged by the rollers or teeth (10) assembled on the support (9); a rotation of the hollow shaft (5) subjecting the support (9) to an orbital movement adapted to take the teeth or rollers of the support to engage the toothing of the idle wheel (12); means adapted to establish a connection between the wheel (12) and a user to which motion is transmitted, wherein it provides means adapted to axially slide the support (9) or the wheel (12) with respect to the shaft (1).

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VARIABLE-RATIO TRANSMISSION DEVICE

The present invention refers to the field of motion transmission kinematisms, particularly for vehicles, and deals, more particularly, with a variable-ratio transmission device that operates continuously, comprising a support with a circular series of teeth or rollers that rotates around a slanted axis, in order to perform an orbital motion, and meshes with a crown with teeth that are parallel to the axis.

In turn, the crown can directly actuate a user such as, for example, a velocipede hub or, according to a preferred embodiment of the invention, from its opposite part the crown can have a second series of teeth that mesh with a circular series of rollers, in turn assembled on a support with slanted axis that is able to perform an orbital movement, said second support being connected to a user.

The system provides for means adapted to axially slide said roller supports, in order to continously change the reduction ratio.

A transmission device is thereby obtained that is composed of a stepless speed change gear, with a ratio among speeds that is continuously variable within an extremely wide range.

As known, it would be highly useful to be able to have available, in vehicles, a transmission with continuously changing ratio, both for a more comfortable and soft driving, and to be able to better exploit the

engine characteristics that, as is well known, provides an optimum efficiency for a well defined rotation speed.

Different types of transmission are known and comprise stepless speed change gears, but these are systems that are excessively encumbrant and cumbersome and that are adapted only for certain types of vehicles but cannot be assembled, for example, on velocipedes such as bicycles, motorcycles or the like.

The present invention belongs to this sector and proposes a continuously variable-ratio transmission device, as claimed in Claim 1, that can find a wide range of applications, also due to the fact that its speed can be changed within an extremely wide range and that, due to its characteristics, is particularly adapted to be used also as applied to velocipedes, such as bicycles, motorcycles, or, made of plastics or other light-weight and sturdy material, to white goods or cutting machines, or the like.

The arrangement of the device according to the invention is such as to allow easily inserting it within an hub of a motorcycle wheel. The description that follows refers, only as a mere example, to the specific case of a transmission device for velocipedes such as bicycles or motorcycles, but it is clear that the same inventive idea can be validly applied also to different fields and that the scope is not limited by the specific case as described, but extends to all pieces of equipment and vehicles that adopt this transmission device.

The present invention will now be described in detail, as a non-limiting example, with reference to the enclosed drawings, in which:

- Figure 1 schematically sectionally shows a first embodiment of a transmission device according to the

invention;

- Figure 2 schematically sectionally shows a further preferred embodiment of the transmission device according to the invention.

With reference to Figure 1, reference 1 points out a fixed shaft, that can for example be the shaft of the driving wheel of a velocipede, on which the transmission device according to the invention is assembled.

The shaft 1 is grooved and an hollow shaft 2 is assembled thereon and can axially slide with respect to the shaft 1.

The hollow shaft 2 position can be changed for example by means of a ring nut 3 or another known system, for example by means of mechanisms with worm screws, or with electronic circuit control.

A pair of hollow shafts 5 and 5' are assembled onto the shaft 2, by interposing bearings, bushings or the like, referenced with 4.

The shaft 5 is the motion inlet shaft and in case of a transmission for velocipedes is stiffly connected to a pinion or a toothed crown 6 that is moved by the chain.

The hollow shaft 5' instead is connected, as will be described below, to the wheel hub, referenced by number 7.

The external surface of the shaft 5 is worked in order to define, at least for a certain length, a cylindrical surface with slanted axis B-B with respect to axis A-A of the support shaft 1.

In practice, following the rotation of the hollow shaft 5 around axis A-A, axis B-B of the slanted length describes a tapered sufrace with its vertex on axis A-A.

On the shaft 5, next to the length with slanted axis, a support 9 is assembled, by interposing bearings

or bushings 8, such support 9 being substantially composed of a disk or a wheel that has, perimetrally, a plurality of teeth or rollers 10 whose axis rests on a plane that is parallel with the support 9 plane.

The rollers 10 are provided to be engaged with the toothing 11 of a wheel 12 assembled idle on a support 13 that is integral with the wheel hub 7.

Bearings or bushings 14 allow the wheel 12 to freely rotate with respect to its own support.

A ring 15 is hinged, through a pair of diametrally opposite pins 16, to the support 9 of the rollers 10. It is therefore possible to rotate the ring 15 relative to the support 9, around a first axis that is substantially parallel to the plane of said support 9.

In turn, the ring 15 is hinged, through two diametrally opposite pins that are offset by about 90° with respect to pins 16, to an external ring 17 that is part of a free-wheeled device that is integral with the internal surface of the hub 7.

The rings 15 and 17 consequently make a sort of cardan joint that allows the support 9 of the rollers 10 to rotate with respect to the ring 11 around a first axis and with respect to the ring 17 around a second axis that is orthogonal with the previous axis.

In practice, due to these chances of movement around two orthogonal axes, the support 9 can perform an orbital movement, taking in succession the rollers 10 to engage the teeth 11 of the wheel 12.

The number of rollers 10 on the support 9 is different from the number of teeth 11 of the wheel 12 that are engaged by the rollers 10.

According to a first embodiment of the invention, the wheel 12 has, from the opposite part to the toothing

11, a symmetrical toothing 11' that engages a series of rollers assembled on the disk support 9' symmetrical to the support 9 and assembled, by interposing bearings, on a length of the hollow shaft 5' that has a slanted axis.

The shaft 5' engages, through a toothing 18, a free wheel 19 that in turn is assembled on a box 20 secured to the hub 7.

This latter one is assembled on the shafts 5 and 5' by interposing bearings 21 that allow the hub to freely rotate with respect to the shafts.

Like support 9, also support 9' is hinged to a ring 15' in turn hinged, according to an axis that is orthogonal to the previous one, to a free-wheel device 17', on the internal surface of the hub 7.

In case of application of the device to motorvehicles, the connection between free wheel 19 and box 20 occurs by interposing one of more clucth disks 22.

The operation is as follows.

Motion from the chain is transmitted to the pinion 6, that in turn rotate the hollow shaft 5.

The consequent rotation of the length with slanted axis for this shaft imparts to the support 9 an orbital movement that takes in succession the rollers 10 to mesh with the teeth 11 of the wheel 12.

The support 9 can also angularly rotate around axis A-A together with the hollow shaft 5 and these movements, orbital and angular ones, are independent and can be algebraically summed.

In practice the support 9 can perform an angular movement around the axis A-A, in practice rotating around this axis and always engaging with the same roller the toothed wheel 12 that is thereby dragged rotating at the same speed of the shaft 5.

The second movement is the orbital one, so that the support 9 assumes a different rotation speed with respect to the eccentric of the shaft 5 and therefore starts "orbiting" by sequentially meshing with the wheel 12, namely with one tooth after the other, like a traditional gear.

In this case, with an orbital movement of the support 9, the wheel 12 is rotated with a reduced angular speed with respect to the angular speed of the hollow shaft 5, with a reduction ratio that changes depending on the ratio between number of support rollers and number of teeth 11, in addition to the axial position of the support 5, by changing which it is possible to change the lever arm length with which the rollers 10 go and mesh the rollers 10 of the toothed wheel 12, thereby changing the reduction ratio.

At the beginning of operation, the hub 7 is still and prevents the rings 17 and 15 from rotating, so that the support 9 can only perform an orbital movement, rotating the wheel 12 with a certain reduction ratio.

From the opposite part, the teeth 11' mesh with the rollers 10' of the support 9'. The free wheel 17' prevents the assembly from rotating backwards, so that the support 9' is forced to perform an orbital movement that moves it forward.

This movement is transformed into a rotation of the eccentric 5' that can be exploited in order to rotate, through the free wheel 19, the box 20 and with this the hub 7 integral therewith.

As soon as the hub starts rotating through the free wheel 17, it transmits the angular motion to the ring 15 and from here to the support 9 of the rollers 10, which starts rotating around axis A-A, with a rotation motion

that is summed to the orbital motion and that is transmitted to the wheel 12.

Now, the central wheel 12, with toothings 11 and 11', is rotated with two types of meshing, orbital and angular ones, as well as the support 9'.

The angular movement is automatically limited by the number of hub revolutions.

If necessary, like in case of use on a motorvehicle, clutch disks 22 can be used for disengaging the device whtn the vehicle is still, thereby obtaining a transmission device with a ratio that changes continuously and within a very wide range, with compact sizes and adapted for numerous applications, among which vehicles and velocipedes.

In compliance with a second preferred embodiment of the invention, the transmission device can have a simplified configuration that can be seen in Figure 2, that is lacking the second toothing 11', in addition to the second support 9' and the kinematisms downstream of this one.

In this embodiment, particularly suitable for bicycles, the central wheel 12 is directly connected to the hub 7, that is dragged moving at the beginning only due to the orbital motion of the support 9, to which it is overlapped and then, little by little, is replaced by the angular motion.

A skilled person in the art will then be able to provide numerous modifications and variations, that will however have to be deemed all included within the scope of the present invention as claimed in the following Claims.

CLAIMS

1. Variable-ratio transmission device characterised in that it provides at least one support (9) for a circular series of rollers (10), said support being assembled idle on a shaft (5) with slanted axis connected to motor means (6), a rotation of said shaft (5) with slanted axis making said support (9) perform an orbital movement that takes it to engage a toothed wheel (12) with front toothing (11), said toothed wheel (12) with front toothing (11) being connected to a user, and means (2, 3) being provided adapted to axially slide said at least one support (9), in order to change a reduction ratio.

2. Variable-ratio transmission device according to claim 1, characterised in that said toothed wheel (12) with front toothing (11) has, on an opposite part to said toothing (11), a second series of teeth or rollers (11') that engage a series of rollers or respectively teeth assembled on a support (9') connected to a user, means (2, 3) being provided adapted to axially slide one or both of said supports (9, 9') in order to change a reduction ratio.

3. Variable-ratio transmission device characterised in that it comprises:

- a support shaft (1);
- an hollow shaft (5) rotatingly assembled onto said support shaft (1);
- a support (9) assembled onto said hollow shaft (5) in a rotating way with respect to said hollow shaft (5) around a slanted axis with respect to an axis of said support shaft (1);
- a plurality of rollers or teeth (10) arranged in a circular series on said support (9);

- a wheel assembled idle onto said support shaft (1), equipped with a front toothing (11) adapted to be engaged by said rollers or teeth (10) assembled on said support (9);
- a rotation of said hollow shaft (5) subjecting said support (9) to an orbital movement adapted to take said teeth or rollers (10) of said support (9) to engage said toothing (11) of said idle wheel (12);
- means adapted to establish a connection between said wheel (12) and a user to which motion is transmitted, characterised in that it provides means adapted to axially slide said support (9) or said wheel (12) with respect to said support shaft (1).

4. Transmission device according to claim 3, characterised in that it provides on said toothed wheel (12), from an opposite part to said front toothing (11), a further front toothing (11') that engages the rollers of a second support (9') assembled with its axis slanted on an hollow shaft (5') that is also assembled onto said shaft (1), said second hollow shaft (5') being connected to a user such as an hub of a velocipede.

5. Transmission device according to claim 4, characterised in that said second hollow shaft (5) is connected through a free wheel to an hub box.

6. Transmission device according to claim 5, characterised in that it provides, on an internal part of the hub, a pair of free wheels (17, 17') to which a pair of rings (15, 15') are respectively hinged, in turn respectively hinged to the supports (9, 9') so that said rings (15, 15') can rotate with respect to said free wheels (17, 17') around a first axis and with respect to said supports (9, 9') around a second axis that is

orthogonal with the first axis.

7. Transmission device according to claim 6, characterised in that said hollow shafts (5, 5') are rotatingly assembled on a grooved hollow shaft (2), in turn only slidingly assembled onto said support shaft (1).

8. Transmission device according to any one of claims 2 to 7, characterised in that it provides said wheel (12) with double front toothing assembled on a central ring-shaped support (14), in turn assembled onto a support that is integral with the wheel hub.

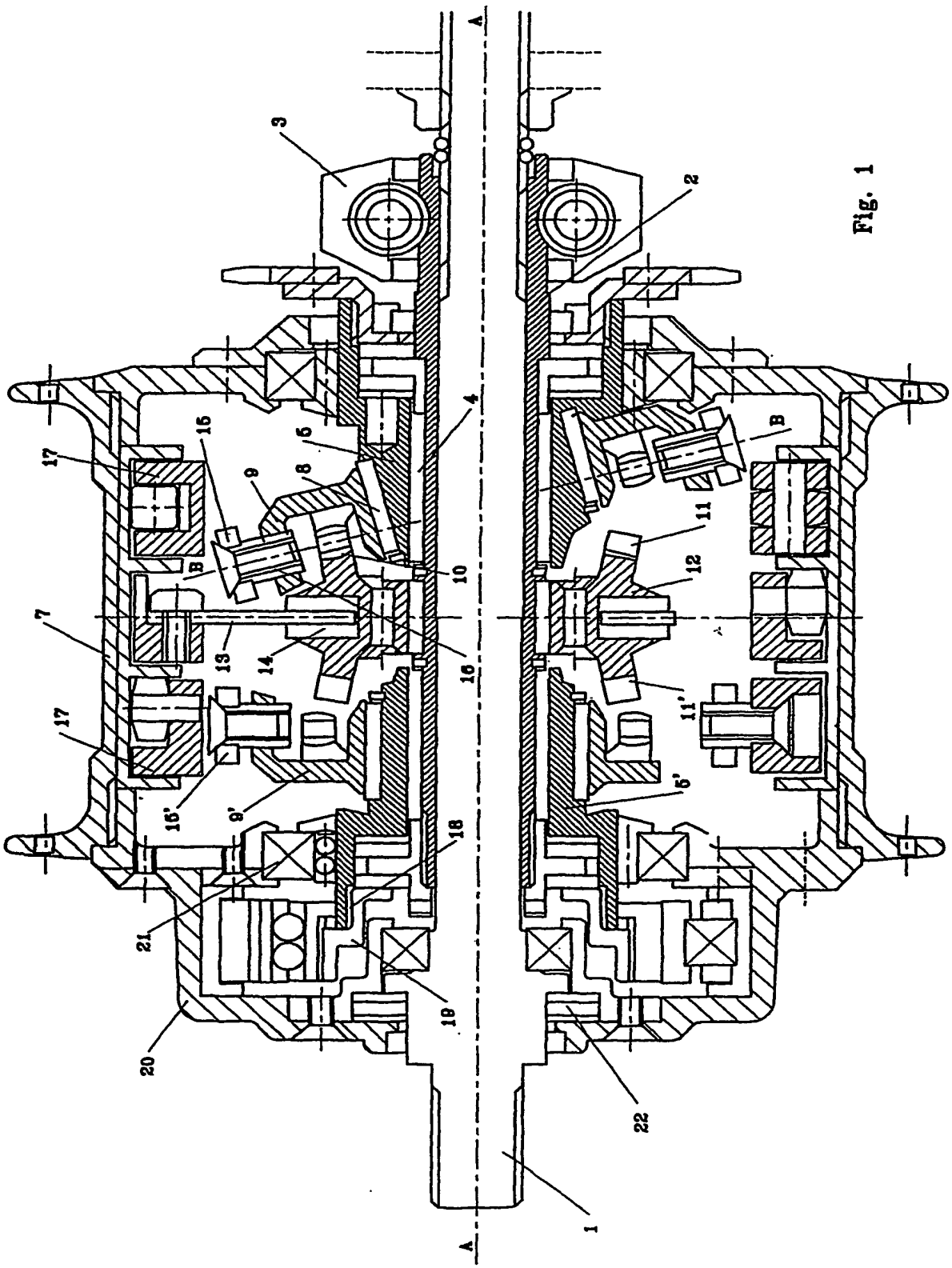

Fig. 1

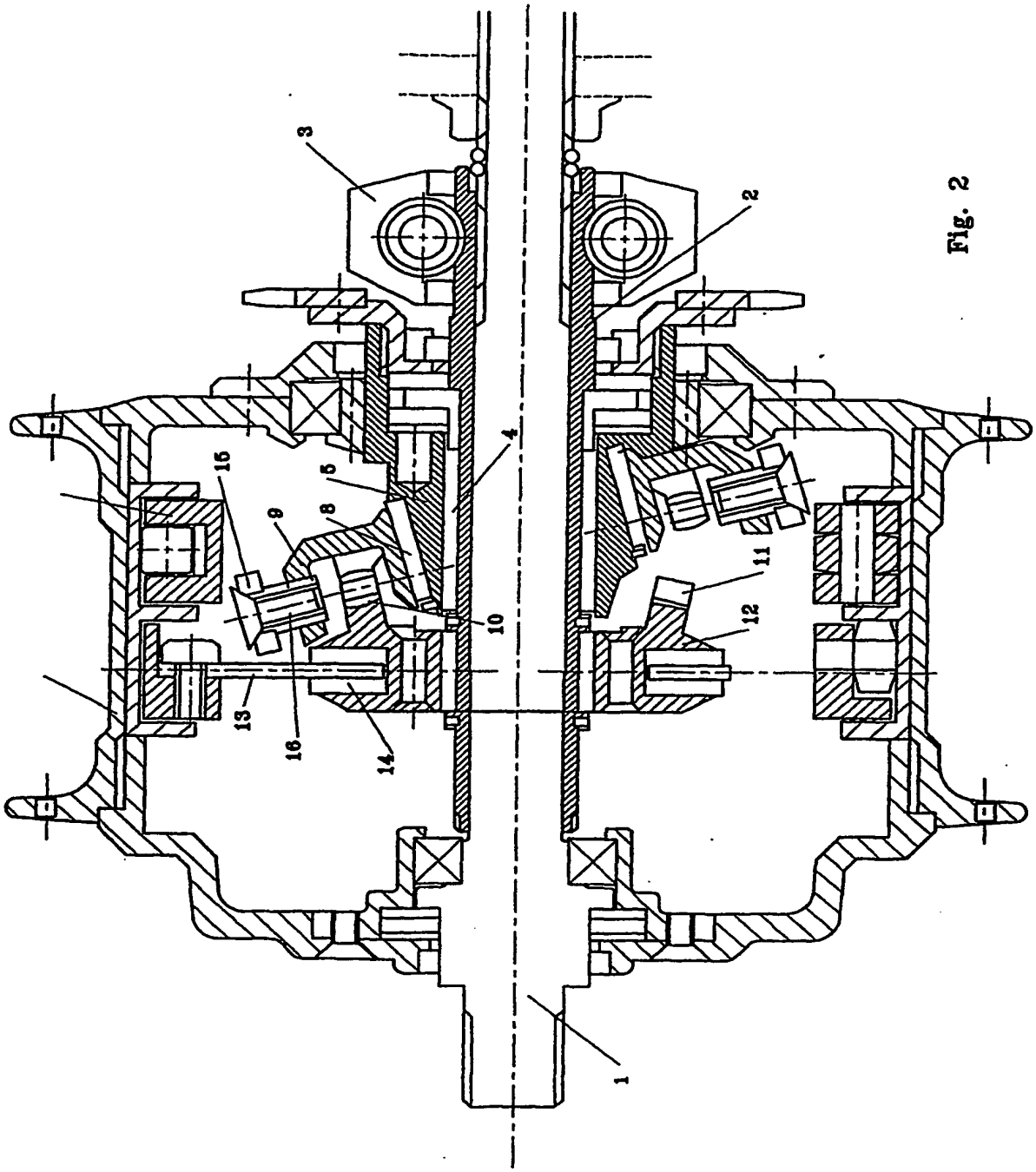

Fig. 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IT 03/00802

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16H1/32 F16H3/76

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F16H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 1 798 269 A (NIETSCHE HANS E) 31 March 1931 (1931-03-31) figures 6,8	1,3
A	GB 1 069 814 A (WALTER BLAZO) 24 May 1967 (1967-05-24) page 3, column 2	1-4
A	US 1 896 462 A (NIETSCHE HANS E) 7 February 1933 (1933-02-07) figures	1
A	US 4 266 446 A (FRITSCH JOSEPH E) 12 May 1981 (1981-05-12) figures	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search	Date of mailing of the international search report
20 April 2004	26/04/2004

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/IT 03/00802

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 25 16 474 A (FICKELSCHER) 2 September 1976 (1976-09-02) column 4, paragraph 2	1
A	US 1 771 807 A (MITCHELL BENJAMIN A) 29 July 1930 (1930-07-29) figures	1
A	DE 42 12 613 A (SCHMIDT LOTHAR WERNER DIPL ING) 21 October 1993 (1993-10-21) column 2, line 62 - line 67	1
A	US 3 895 540 A (DAVIDSON ROBERT) 22 July 1975 (1975-07-22) column 5, line 45 - line 55	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IT 03/00802

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 1798269	A	31-03-1931	NONE		
GB 1069814	A	24-05-1967	NONE		
US 1896462	A	07-02-1933	NONE		
US 4266446	A	12-05-1981	NONE		
DE 2516474	A	02-09-1976	DE	2516474 A1	02-09-1976
			AR	209481 A1	29-04-1977
			AU	1309976 A	20-10-1977
			BE	840223 A1	16-07-1976
			BR	7602348 A	05-10-1976
			CA	1039976 A1	10-10-1978
			DD	125803 A5	18-05-1977
			DK	175676 A	16-10-1976
			ES	447039 A1	01-06-1977
			FI	761027 A	16-10-1976
			FR	2308024 A1	12-11-1976
			GB	1548765 A	18-07-1979
			GR	59915 A1	20-03-1978
			HU	172443 B	28-09-1978
			IL	49371 A	30-04-1978
			IN	144439 A1	06-05-1978
			IT	1058112 B	10-04-1982
			JP	51126467 A	04-11-1976
			LU	74778 A1	11-11-1976
			MC	1115 A	18-05-1977
			NL	7603942 A	19-10-1976
			NO	761319 A	18-10-1976
			PT	65010 A ,B	01-05-1976
			RO	78449 A1	26-02-1982
			TR	19222 A	01-06-1978
			US	4041808 A	16-08-1977
			ZA	7602253 A	27-04-1977
US 1771807	A	29-07-1930	NONE		
DE 4212613	A	21-10-1993	DE	4212613 A1	21-10-1993
			AU	4039393 A	18-11-1993
			WO	9321461 A2	28-10-1993
US 3895540	A	22-07-1975	AU	6317673 A	05-06-1975
			BE	808986 A1	16-04-1974
			CH	575086 A5	30-04-1976
			DE	2364062 A1	04-07-1974
			ES	421787 A1	16-04-1976
			FR	2212895 A5	26-07-1974
			GB	1462850 A	26-01-1977
			GB	1462061 A	19-01-1977
			IN	139154 A1	15-05-1976
			JP	49101766 A	26-09-1974
			PL	89622 B1	30-11-1976
			SE	406359 B	05-02-1979
			ZA	7308845 A	30-10-1974